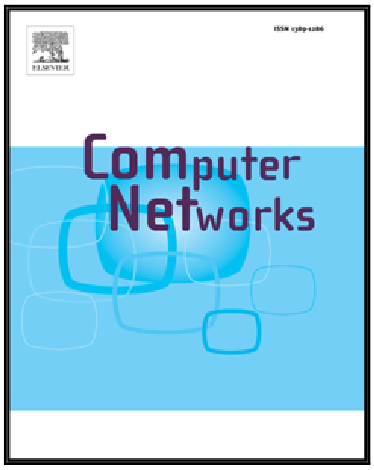
Accepted Manuscript



Ant colony optimization algorithm with Internet of Vehicles for Intelligent Traffic Control System

Priyan Malarvizhi Kumar , Usha Devi G ,
Gunasekaran Manogaran , Revathi Sundarasekar ,
Naveen Chilamkurti , R. Varatharajan

PII: S1389-1286(18)30484-5
DOI: https://doi.org/10.1016/j.comnet.2018.07.001
Reference: COMPNW 6531

To appear in: *Computer Networks*

Received date: 21 December 2017
Revised date: 21 May 2018
Accepted date: 2 July 2018

Please cite this article as: Priyan Malarvizhi Kumar , Usha Devi G , Gunasekaran Manogaran , Revathi Sundarasekar , Naveen Chilamkurti , R. Varatharajan , Ant colony optimization algorithm with Internet of Vehicles for Intelligent Traffic Control System, *Computer Networks* (2018), doi: https://doi.org/10.1016/j.comnet.2018.07.001

Ant colony optimization algorithm with Internet of Vehicles for Intelligent Traffic Control System

Priyan Malarvizhi Kumar [1], Usha Devi G[2], Gunasekaran Manogaran[3], Revathi Sundarasekar[4], Naveen Chilamkurti[5], R. Varatharajan[6]

[1]*School of Information Technology and Engineering, VIT University, Vellore, India,* *priyanit085@gmail.com;*
[2]*School of Information Technology and Engineering, VIT University, Vellore, India,* *ushadevi.g@vit.ac.in*
[3]*University of California, Davis, USA,* *gmanogaran@ucdavis.edu*
[4]*Anna University, Chennai, India,* *revathisundar161@gmail.com*
[5]*Department of Computer Science and Computer Engineering, LaTrobe University, Melbourne, Australia,* *n.chilamkurti@latrobe.edu.au*
[6]*Sri Ramanujar Engineering College, Chennai, India,* *varathu21@yahoo.com*

Abstract

Vehicles present on the Internet of Vehicles (IoV) can communicate with each other in order to determine the status of the road and vehicle in real time. These parameters are used to estimate the average speed and identify the optimal route to reach the destination. However, the government traffic departments are unable to use these valuable traffic data and thus more traffic jam, congestion and road accident occurs. In order to overcome this issue, this paper proposes an effective traffic control system with the help of IoV technology. The proposed method is demonstrated in the study are of Vellore district, Tamil Nadu, India. The street maps are segmented into number small number of distinct maps. Ant colony algorithm is applied to each map in order to find the optimal route. In addition, Fuzzy logic based traffic intensity calculation function is proposed in this paper to model the heavy traffic. The proposed IoV based route selection method is compared with the existing shortest path selection algorithms such as Dijikstra algorithm, Kruskal's algorithm and Prim's algorithm. The experimental results proved the good performance of the proposed IoV based route selection method.

Keywords: Internet of Vehicles; Effective Traffic Control; Shortest Path Selection; Dijikstra algorithm; Kruskal's algorithm; Prim's algorithm

1. Introduction

Internet of Vehicles (IoV) paradigm originally developed with the help of Internet of Things (IoT) technology. IoV is widely used in various environments it includes communications, transportation, information and automotive technology. The Internet of Vehicles (IoV) is an expected conjunction of the Internet of Things and the mobile Internet. The IoV comprised of all current and new vehicles, either integrated or fitted with two-way RF equipment [51,52]. The IoV uses Vehicle-to-Vehicle (V2V), Vehicle-to-Road (V2R), Vehicle-to-Human (V2H) and Vehicle-to-Sensor (V2S) communication networks to communicate between public networks and vehicles. It is predicted that more than 80% of vehicles sold globally in 2020 will be connected, either by smart-phone or embedded device integration [53].

IoV is one of the possible technologies to improve road safety, and provide in-car entertainment and on-board Internet services, such as, social networking, online media streaming, online navigation and real-time traffic report acquisition. Nowadays, a range of computing technologies such as “5G”, “cloud computing” and “big data” have been used to monitor the vehicles, road traffic analysis, accident identification system [54,55]. Moreover, the convergence of IoV technology encompasses environmental protection, information communications, energy conservation, and safety. Due to the rapid growth in connected vehicles, many research issues need to be addressed it includes security, privacy and trust, network resource optimization and QoS guarantee for IoV [56].

Internet of Everything comprises of IoT and IoV. The Internet of Everything is used to connect various physical devices and user products with the help of Internet. It is assumed that in future all the devices will be connected to the Internet and all operations are done with the help of Device to Device (D2D) communication. The following technologies are plays a vital role in Internet of Everything it includes Device to Device Communications, Machine-to-Machine communications, Machine to People Communications, and People to People Communications. Nowadays, IoE is used in many applications in terms of good performance and response time. The major applications of IoE in vehicles and road network include smart traffic monitoring, smart parking system and self-drive cars.

In addition, IoE is also used to monitor the human health (personal health monitoring of patients, smart drug recommendation system and smart clinical care system). People can use smart devices such as smart watch, smart belt and smart band to observe their health status. The collected data from the various smart healthcare devices are transmitted to the doctor and clinical care system to take necessary actions. Nowadays, various smart wearable devices are identified to collect various health status it include blood pressure, body glucose level, heart rate, body temperature, physical movement and so on. In addition, IoE is also used in various smart home applications such as window control, door control, room temperature maintenance, light control and security alarms. The above mentioned applications are must transfer the signal to the server or user with good response time.

In order to sense and collect various data from IoT devices, there is a need of advance high speed wireless networks. Nowadays, there is a massive improvement and advancement in wireless network technologies such as 4G network to 5G networks. This advancement in wireless network technology enables the physical devices to sense the signal and transfer to the user and server in terms of good response time. Moreover, the 5G network is also used to overcome the various issues in wireless networks it includes network connectivity, latency issues and improve the data transfer speed between the various IoT devices and user or server. The above mentioned advanced technologies such as IoT, IoE and 5G mobile network are used to change the day-to-day environment of individual's life.

Vehicular Ad-Hoc Networks (VANETs) is a subclass of mobile ad hoc networks (MANETs). In recent years, VANETs play an important role in intelligent transportation system. In addition, VANETs do not follow any fixed infrastructure and instead they follow dynamic routing principle. Hence, vehicles themselves provide a range of network functionality in dynamic manner. The dissimilar insight of the vehicle in IoV and VANETs creates these two paradigm vary primarily in the communications, networking, device and features. In general, vehicles exist in VANET distribute messages among other vehicles exist in the network. The vehicles present in the VANET are also called as mobile nodes and they follow an inter-vehicle communication network principle.

Table 1. Routing algorithms for traffic control

S.No.	Proposed Approach	Authors	Outcome
1	Delay-optimal VSN routing algorithm	Choi et al. [18]	High packet delivery
2	Vehicle-logo location algorithm	Liu et al. [19]	Used to classify the vehicles
3	Symmetric double sided two way ranging algorithm	Saqib et al. [20]	Vehicle tracing system
4	Dynamic traffic monitoring system	Arbabi et al. [21]	Monitoring of travel time and location
5	Intelligent traffic flow control system using RFID	Chao et al. [22]	Traffic and accident control
6	Vertical distance vector routing algorithm	Bazzi et al. [23] Alexander et al. [24]	Reliable communication system
7	WSN cross layer design approach	Cabezas et al. [25]	Latency and jitter are improved
8	User customizable data-centric routing.	Zhou et al. [26]	Fast traffic information delivery
9	GPS based tracking system	Mazloumi et al. [27]	Reduced travel time and shortest path
10	Traffic monitoring system using Bluetooth	Friesen et al. [28]	Monitoring vehicle density
11	Urban monitoring system	Bruno et al. [29]	Less redundancy information and consumes less network bandwidth.

In addition to VANETs, the following dynamic vehicular mobile communication systems are exist in the day-to-day environment it includes Vehicle to Human (V2H), Vehicle to

Infrastructure (V2I) and Vehicle to Internet Vehicle to Sensor (V2S). Nowadays, cloud computing technology has considered as a new emerging environment to address various issues exist in the real time environment it includes healthcare analytics, education development, business process, natural resource monitoring and so on. Liu [2] proposed a novel three-level "Client-Connection-Cloud" system to monitor and control the vehicles with the help of Cloud-Assisted IoV (CAIV) system. The objective of CAIV system is to monitor, actuate and navigate the embedded sensor vehicles and other devices in the cloud virtually.

Table 2. Congestion avoidance techniques in traffic control

S.No.	Proposed Approach	Authors	Outcome
1	Evaluation of traffic signal control algorithms	Ahmad et al. [30]	Execution time measurement
2	Traffic control using VANET	Knorr et al. [31]	Traveling time significantly reduced
3	Adaptive traffic flow algorithm	Abishek et al. [32]	Reduce Congestion
4	Traffic random early detection algorithm	Laisheng et al. [33]	Reduce Congestion
5	Traffic model using wireless traffic lights	Dragoi et al. [34]	Travel time reduced up to 40%.
6	Circuit patrol and Greedy patrol algorithms for traffic control	Du et al. [35]	The traffic estimation error is significantly minimized
7	ZigBee based traffic flow control system	Eren et al. [36]	Smooth traffic flow and less end-to-end delays
8	Data spreading algorithms for traffic data acquisition	Skordylis et al. [37]	High packet delivery ratio, low delivery delay and less communication cost

The CAIV system process and manage the large volume of data collected from physical components in a real-time, scalable, on-demand, reliable and efficient manner. Moreover, the integration of cloud computing paradigm with IoV seems to be a significant method to advancing the real time applications. Especially, elastic re-configuration, virtualization, and multi-tenancy of resources are found to be a significant method in cloud computing to store and process the large volume of data (big data) generated from IoV environments. Nowadays, a number of researchers have developed many real time IoV architectures and cloud based data analytical methods to monitor, actuate and navigate the embedded sensor vehicles.

The advancements in IoV technologies help to make transportation safer, cleaner and more effective. In recent years, IoV plays an important role in the clean traffic environment. This would also improve traffic efficiency and reducing the pollution and travel time. The Mobile

Crowd Sensing (MCS) technology is found to be a significant solution to monitor and control the traffic congestion. In MCS, a number of mobile devices such as sensor-equipped vehicles and smartphones are used to transfer the traffic data to the traffic monitoring system. Afterwards, the results or shortest path identified by the traffic data analysis is forwarded to the traffic authorities of the traffic situation or drivers.

Section 1 presents the introduction about IoV, VANET, mobile networks and current traffic issues. The recent works done in IoV based traffic control system is described in section 2 in detail. The proposed IoV based traffic control and best route identification method is presented in section 3. The results are discussed in section 4. The performance of the proposed IoV based traffic control and best route identification method is evaluated in section 5. Finally, section 6 concludes the research work with a summary of results.

2. Related work

IoV is used to monitor the patients' health status in the following ways it includes in-ambulatory, in-hospital, in-clinic, and open environment monitoring. However, there is a need for mobile hospital and mobile doctors to provide emergency care services to the patient when the patient health condition getting worse. In order to overcome this issue, various mobile ambulance and mobile doctors are used by the healthcare department to overcome such circumstances. However, there is a need for an effective communication platform to communicate the mobile doctors and to provide the clinical solutions to the patients. In past decades, VANET is widely used to communicate and transfer message between the vehicles.

VANET consists of Vehicle to Vehicle (V2V) and Vehicle to Roadside (V2R) communications to transfer the signals between the vehicles [1]. However, there is need for improving the communication speed between the vehicles [2, 3]. Leng and Zhao have identified the IoT based traffic management system to reduce the road traffic and accidents [4]. In general, vehicles in IoV system can communicate each other, but there is an issue in content distribution among these vehicles. In order to solve this issue, Kumar et al. and Gerla et al. have identified a Markov Decision Process (MDP) based Bayesian coalition game (BCG) as-a-service in cloud to distribute the content among various vehicles in IoV system [5,6]. In addition, Kumar et al. have used Bayesian coalition game (BCG) and learning automata (LA) to process the large volume of spatio-temporal data in IoV system [7]. Paul et al. have proposed the Cooperative Cognitive Intelligence architecture to solve spectral scarcity and high mobility issues in mobile networks [8]. In addition, a various cloud service providers provides various services to implement the IoV system. In order to select the best cloud service, Hoang and Niyato have identified the gaming method to solve pricing competition in IoV system [9]. Nowadays, a number of vehicles are used daily by more and more people and thus more issues and delay exist in vehicle toll payment system [10].

In order to overcome this issue, Pašalić has identified the IoT based vehicle toll payment system [11]. Similarly, Alam and Vrushali Pavitrakar have identified the platform to share the transport related travel safety rules, efficiency, and comfort techniques with other vehicles [12, 13]. In addition, Nitti and Alam have used VANET and Social Internet of Things to find the social relationship between the vehicles in IoV system [14, 15]. Similarly, Wan et al. have developed a mobile crowd sensing technology to solve heavy traffic issues in road networks [16]. Prinsloo and Malekian have developed the RFID based accurate vehicle location system to find the vehicles in efficient and real time manner [17]. The comparisons of existing works are surveyed and listed as shown in the Table1. The analysed detail consists of architectures, routing algorithms and data collection schemes of various existing methods. The trickiness situation on roads is said to be traffic congestion. The traffic congestion can be typified based on queuing, slower vehicle speeds and longer trip times. The WSN-based techniques and schemes are used to reduce traffic congestion. These techniques are surveyed and listed as a table 2.

3. Internet of Things for Connected Vehicles

More commonly, Internet connection is used for the laptop, PDA, desktop computers and tablets to store and transfer the data. As advancements in wireless technologies and smart devices, various types of physical devices are identified to sense the various signals with the help of Internet. These devices are connected with the Internet and transfer the signals to the server in continuous manner. For example, advanced wearable medical devices such as body temperature belt and heart pressure watch are implanted with the human body to observe the specific health measure. These health measures are collected and transfer to the doctor or healthcare department in continuous manner. In addition, more applications of IoE include smart vehicle driving system, smart city, smart traffic control and weather monitoring applications. IoE technologies are classified in to various types such as digital sensor devices, smart interconnected wireless devices, smart industrial monitoring devices and various distributed hardware technologies. Recently, IoE is applied in information technology field to improve the business process. Especially, Cisco is one of the head institute for network technologies who has started using IoE devices for network applications. IoE is basically consists of four connections parts such as People, Things, Data and Process.

The term people represent the users on the IoE where the collected information from one individual is transferred to another with the help of internet. In recent years, people are interested to connect with each other via internet and to share data among them. Nowadays, PCs, TVs, tablets, and smart phones are used to connect the people and transfer the valuable information. Moreover, all the individuals are already connected with the internet with the help of social networking sites such as Twitter, Facebook and LinkedIn. In recent years, due to advancement in internet towards IoE, individuals are able to connect each other in more related and helpful ways.

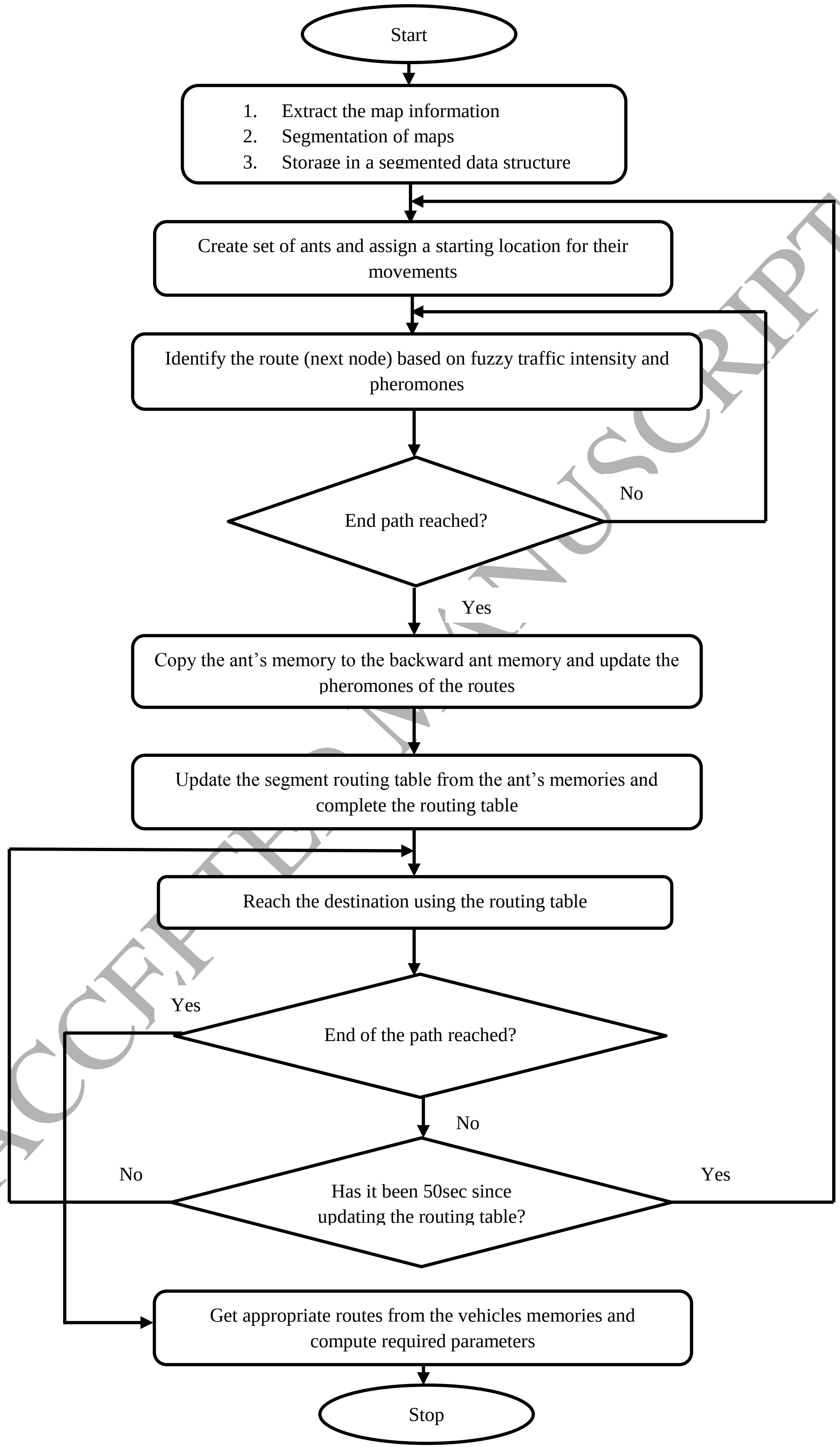

Start
1. Extract the map information
2. Segmentation of maps
3. Storage in a segmented data structure
Create set of ants and assign a starting location for their movements
Identify the route (next node) based on fuzzy traffic intensity and pheromones
End path reached?
No
Yes
Copy the ant's memory to the backward ant memory and update the pheromones of the routes
Update the segment routing table from the ant's memories and complete the routing table
Reach the destination using the routing table
End of the path reached?
Yes
No
Has it been 50sec since updating the routing table?
No
Yes
Get appropriate routes from the vehicles memories and compute required parameters
Stop

Fig. 1. Workflow of the proposed method

Things are play a vital role in IoE system to sense the valuable information from the physical devices that are connected with the internet. Data collected from the physical devices are used to enable the users to take a better decision when an emergency situation arises at an event. For example, when the patient health condition is worse ever before then alarm will be switch on and a notification will be send to the doctor or care holder. The sensor data collected from various IoT medical devices is transferred into the data store to process and make effective decisions when an emergency situation arises at an event.

The devices connected to the internet are used to collect the valuable information from the individuals or things. The IoT devices are usually sense a specific data and stream it over the internet. The collected data will be stored in the sensor server to process and extract the high value hidden information. Unprocessed data collected from various physical devices are analyzed and appropriate actions are taken at necessary time. For example, in healthcare industry, high and low glucose levels are used to monitor the normal glucose level of the patient in the healthcare department.

Processes play a vital role in monitoring the functions of data, people, and things. Processes are also used to bring the valuable information from the interconnection of data, people, and things. Accurate processes and connection are used to transfer the appropriate information and add value to the IoE system. The processes are uses various advanced wireless network technologies to transfer the valuable information to the destination. Nowadays, 5G mobile network are widely used in IoE system to transfer the data generated from the physical devices which are connected in the internet. The strong connection network between the devices, data, and individuals are used to identify business insights from IoE technologies. Recently, social networks and wearable devices are used to promote pertinent healthcare contributions to potential users.

4. IoV based intelligent traffic management

In recent decades, man-to-man and man-to-machine communications are often used in many applications in wireless networks. Nowadays, due to advancement in wireless technologies (4G networks, 5G networks and LTE) the man-to-man and man-to-machine communication are enhanced as machine-to-machine (M2M) communication network. This advancement is used to enhance and improve the field of vehicle-to-vehicle (V2V) communication network. Moreover, the devices fixed in the machine-to-machine (M2M) network are always in moves dynamically from source to destination.

M2M communication is used in many applications it includes smart home, E-haelth, robotics, smart cities and wearable medical devices [38]. Sensors, actuators, routers, Wi-Fi and 4G/5G mobile networks are playing a vital role in M2M communication networks. In recent decade, there is need to have an external environment or platform to support the communication between the sensor devices and server [39, 40, 41]. The communication platform would create more computation cost and overhead. In order to overcome this issue, M2M communication networks are identified with an advance communication technology. This advancement is used to enable the direct communication between source and destination without need for any additional platform or environment [42].

Moreover, senor devices are often used to observe the specific signal and transmit to the server. Once the server received the signal from the sensor devices then it takes a necessary action based on the signal received from the sensor. It would create latency and transmission delay in wireless communication [43]. In order to overcome this issue, Device-to-Device (D2D) is identified with the help of advance sensor communication technologies. More specifically, spectral bandwidth is used in the D2D communication to transfer the messages between the nearby mobile devices [44]. Recently, D2D communication networks are combined with 4G LTE advance mobile communication to reduce the transmission delay and latency in the data transmission [45]. The advancement in D2D communication also used to enable the mobile devices to transfer the large volume of data between the nearby mobile devices. In addition, D2D communication networks do not require any external environment or platform to enable the connection between the nearby mobile devices [46].

Vehicle-to-vehicle (V2V) communication network is used to transfer the signal and information between the vehicles [47]. More commonly, the vehicle driving speed, geo location of the vehicle, travel direction, breaking data and lack of stability are transferred between the vehicles in V2V communication networks [48]. The V2V communication networks use a dedicated short-range communications (DSRC) between the vehicles [49]. As bus, car and smart traffic monitor transfer the data between the nearby vehicles, mesh network is widely used in V2V communication [50]. Generally, 5 to 10 hops are used to transfer the traffic signal for 1 mile distance. For example, if any driver chooses a wrong route then the V2V system enables the alarm or flashes the red light in the front panel.

In this paper, we have proposed a novel IoV based traffic management method to prevent heavy traffic formation and accidents. The proposed method is demonstrated on the study are of Vellore district, Tamil Nadu, India. The street maps are segmented into number small maps. Ant colony algorithm is applied on each map in order to find the optimal route. In addition, Fuzzy logic based traffic intensity calculation function is proposed in this paper to model the heavy traffic. The proposed IoV based traffic management method is applied for a continuous health monitoring system. The proposed method is classified into four stages as follows: map segmentation and graph conversion, ant colony optimization algorithm, computation of traffic intensity and Pheromone update. Fig. 1 represents the workflow of the proposed method.

4.1 Map Segmentation and Graph Conversion

The street maps are segmented into several parts with almost identical sizes. The segmented maps are used to model the dynamic vehicular environments. Moreover, significant routes are identified in each segmented maps independently instead of using whole map.

The segmented maps are converted to a graph where each graph is represented by set of nodes and links.

$G_N = (O_N, P_N)$ (1)

Where,

O_N= represents the set of nodes

L_M = represents the set of links

The segment routing table is maintained in each segment and updated dynamically. The Segment Routing Table (R_{ti}) is defined by,

$R_{ti} = G_{Ni} = (O_{Ni}, P_{Ni})$ (2)

Where,

R_{ti} = represents the routing table for segment i (i=1,2,…,n) where n represents the number of number of nodes in a segment.

Once the map is segmented and routing table is formed, then the ant colony algorithm is applied for each segment to update all edges and identify the best route.

Procedure of ACS algorithm

Begin

Initialize

While stopping criterion not satisfied do

Position each ant in a starting node

Repeat

For each ant **do**

Choose next node by applying same transition rule

Apply step by step pheromone update

End for

Until every ant has built a solution

Update best solution

Apply offline pheromone update

End while

End

4.2 Ant Colony Optimization Algorithm

The proposed ant colony algorithm uses forward ant and backward ant procedures to identify the optimal route to reach the destination. The number of vehicles currently moving on a road and the road length are collected simultaneously with the help of IoV technology. The computation of maximum number of vehicles $Max_{NV_{ij}}$which can be on the road is defined by,

$$Max\_NV_{ij} = \frac{LL_{ij}}{L_V + \Delta L} \times NL_{ij} \qquad (3)$$

Where,

LL_{ij} = represents the length of the road

NL_{ij} = represents the number of roads in a street between node i and j

ΔL = represents the average distance between two vehicles

L_V = represents the average length of vehicles

In this paper, ΔL and L_V are taken as 3 m and 5 m respectively. The computation of density of vehicle (D_{ij}) is defined by,

$$D_{ij} = \frac{NV_{ij}}{Max\_NV_{ij}} \qquad (4)$$

In ant colony optimization, forward ants are used to find the optimal and shortest path to reach the destination. The movement of new position is defined by the forward ants as follows:

$$p_{ij}^{k}(t) = \begin{cases} \frac{a(\partial_{ij}) + b(1-\eta_{ij})}{\sum_{h \notin tabu_k} a(\partial_{ij}) + b(1-\eta_{ij})} \times \left(\frac{1}{1+\frac{1}{N_j}} \right) & if\ j \notin tabu_k, \\ 0 & otherwise \end{cases} \qquad (5)$$

Where,

∂_{ij} = represents the pheromone value of an ant in node i to move to node j and is calculated by backward ants using Equation (7).

η_{ij} = represents the instantaneous state of the fuzzy value on the link from i to j and calculated by vehicle as ant.

a = represents the weight for the importance of ∂_{ij}

b = represents the weight for the importance of η_{ij}

$tubu_k$= represents the set of nodes connected to node i that an ant k has not visited yet

N_j = represents number of neighbors for node j

If a forward ant reaches its destination, then the forward ant changes as a backward ant. Hence, the memory of forward ant is used by the backward ant to find optimal route.

4.3 Calculate fuzzy traffic intensity

The traffic intensity is computed with the help of two input parameters namely the number of lines (NL_{ij}) and present traffic on the same link. On the basis of NL_{ij} and present traffic the current instantaneous congestion state (D_{ij}) is computed dynamically.

As shown in Table 3 and Table 4, the fuzzy linguistic variables, Lines and Traffic are used as a input variable and Intensity is considered as a output variable.

Table 3 Lines and Traffic

Linguistic Variable	Fuzzy Membership Function
Very Low (VL)	(0,0,0.25)
Low (L)	(0,0.25,0.5)
Medium (M)	(0.25,0.5,0.75)
High (H)	(0.5,0.75,1)
Very High (VH)	(0.75,1,1)

Table 4 Intensity

Linguistic Variable	Fuzzy Numbers
Very Low (VL)	(0,0,1)
Low (L)	(0,1,3)
Medium Low (ML)	(1,3,5)
Medium (M)	(3,5,7)
Medium High (MH)	(5,7,9)
High (H)	(7,9,10)
Very High (VH)	(9,10,10)

The fuzzy inference system is defined by,

$$\mu_{Lines\cap\text{Traffic}} = \min(\mu_{Lines}, \mu_{Traffic}) \qquad (6)$$

The traffic intensity is represented as $\overline{y_i} = \{0.01,0.15,0.3,0.5,0.7,0.85,1\}$ and the average defuzzifier is defined by,

$$\eta_{ij} = y_i^* = \frac{\sum_{i=1}^{20} \overline{y_i} \times \mu_{Lines\cap\text{Traffic}}}{\sum_{i=1}^{20} \overline{y_i}} \qquad (7)$$

4.4 Pheromone update

The pheromone value of links is updated on the basis of backward ants' arrival time. The function to increase and decrease the pheromone value is defined by,

$$\tau_{ij}^{new} = (1-\rho)\tau_{ij}^{old} + \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \qquad (8)$$

Where,
$\rho \in A[0,1]$ represents the pheromone evaporation value
m = represents the number of nodes in the same segment

The computation of pheromone placed on links i and j by ant k is defined by,

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{1}{LL_{ij}^{k}} + \frac{1}{TT_{ij}^{k}} + \frac{1}{D_{ij}^{k}} \; if\ the\ k^{th}\ ant\ pass\ link\ i-j, \\ 0 \qquad\qquad\qquad\qquad otherwise, \end{cases} \quad (9)$$

Where,

TT_{ij}^{k} = represents the travel time

D_{ij}^{k} = represents the vehicle density

LL_{ij}^{k} = represents the length of each link which traverse by ant k

5. Performance Evaluation

The proposed IoV based route selection method is compared with the existing shortest path selection algorithms such as Dijikstra algorithm, Kruskal's algorithm and Prim's algorithm. The experimental results proved the good performance of the proposed IoV based route selection method. The average travel time and average waiting time are calculated for dynamic size of vehicles. The experimental results are depicted in Fig. 2 and Fig. 3.

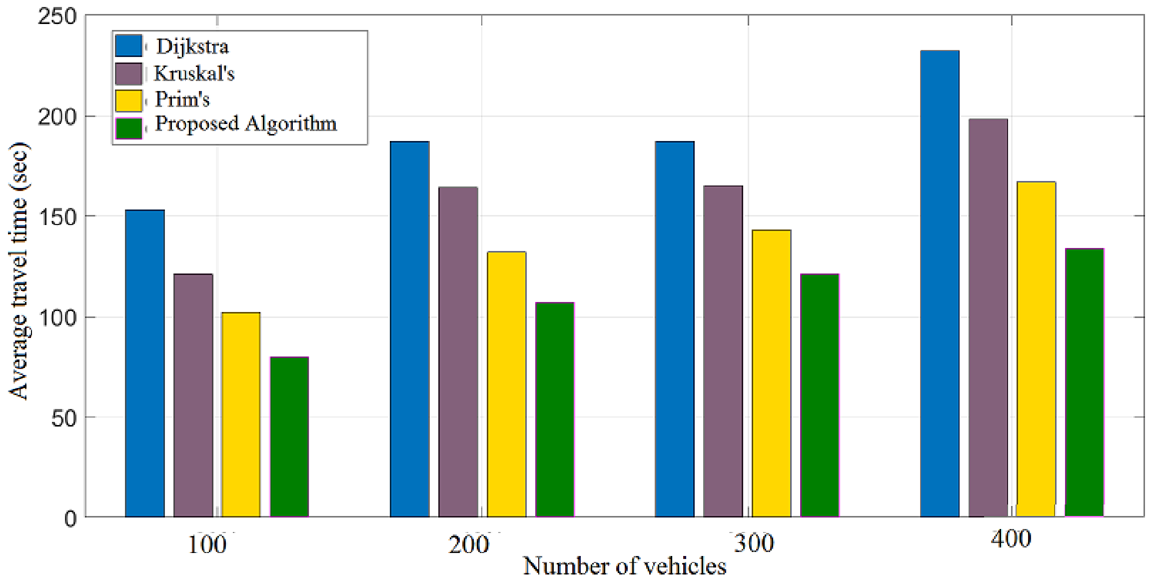


Fig. 2 Average travel time

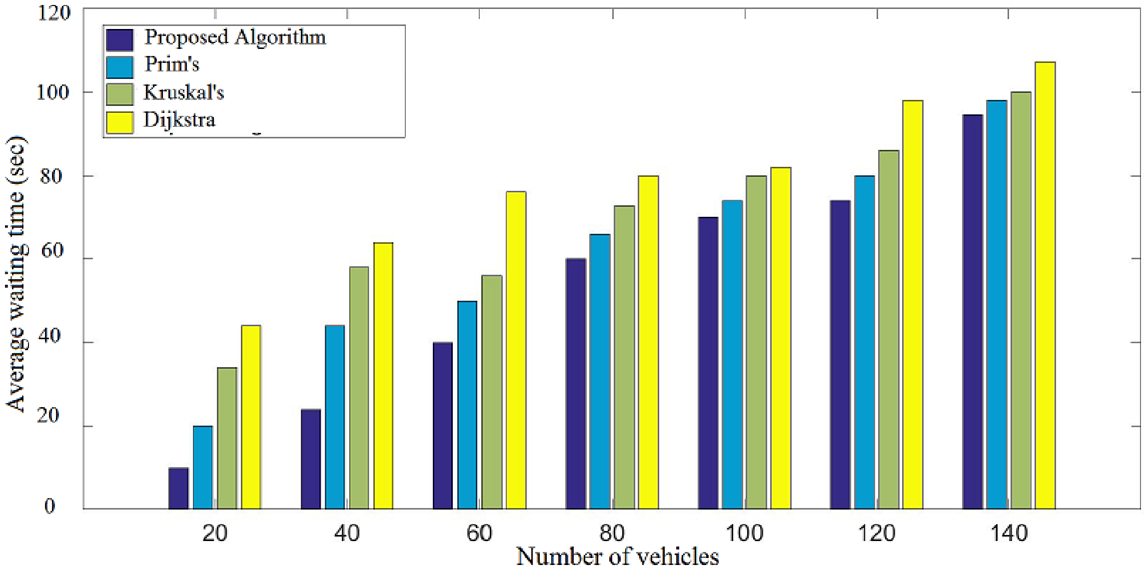


Fig. 3 Average waiting time

6. Conclusion

This paper proposed a novel IoV based traffic management method to prevent heavy traffic formation and accidents. The proposed method is demonstrated on the study are of Vellore district, Tamil Nadu, India. The street maps are segmented into number small number of distinct maps. Ant colony algorithm is applied on each map in order to find the optimal route. In addition, Fuzzy logic based traffic intensity calculation function is proposed in this paper to model the heavy traffic. The future work of this paper is to use the proposed IoV based traffic management method for a continuous health monitoring system.

References:

[1] Cheng, C., & Zongxin, W. (2013, December). Design of a System for Safe Driving Based on the Internet of Vehicles and the Fusion of Multi-aspects Information. In *Computational Intelligence and Security (CIS), 2013 9th International Conference on* (pp. 692-696). IEEE.

[2] Sarma, A. C., & Girão, J. (2009). Identities in the future internet of things. *Wireless personal communications*, *49*(3), 353-363.

[3] Dimitrakopoulos, G. (2011, August). Intelligent transportation systems based on internet-connected vehicles: Fundamental research areas and challenges. In *ITS Telecommunications (ITST), 2011 11th International Conference on* (pp. 145-151). IEEE.

[4] Leng, Y., & Zhao, L. (2011, August). Novel design of intelligent internet-of-vehicles management system based on cloud-computing and Internet-of-Things. In *Electronic and Mechanical Engineering and Information Technology (EMEIT), 2011 International Conference on* (Vol. 6, pp. 3190-3193). IEEE.

[5] Kumar, N., Rodrigues, J. J., & Chilamkurti, N. (2014). Bayesian coalition game as-a-service for content distribution in internet of vehicles. *IEEE Internet of Things Journal*, *1*(6), 544-555.
[6] Gerla, M., Lee, E. K., Pau, G., & Lee, U. (2014, March). Internet of vehicles: From intelligent grid to autonomous cars and vehicular clouds. In *Internet of Things (WF-IoT), 2014 IEEE World Forum on* (pp. 241-246). IEEE.
[7] Kumar, N., Misra, S., Rodrigues, J. J., & Obaidat, M. S. (2015). Coalition games for spatio-temporal big data in internet of vehicles environment: a comparative analysis. *IEEE Internet of Things Journal*, *2*(4), 310-320.
[8] Paul, A., Daniel, A., Ahmad, A., & Rho, S. (2015). Cooperative cognitive intelligence for internet of vehicles.
[9] Hoang, D. T., & Niyato, D. (2016, February). Information service pricing competition in Internet-of-Vehicle (IoV). In *2016 International Conference on Computing, Networking and Communications (ICNC)* (pp. 1-5). IEEE.
[10] Alam, K. M., Saini, M., & Saddik, A. E. (2015). Workload model based dynamic adaptation of social internet of vehicles. *Sensors*, *15*(9), 23262-23285.
[11] Pašalić, D., Cvijić, B., Bundalo, D., Bundalo, Z., & Stojanović, R. (2016, June). Vehicle toll payment system based on Internet of Things concept. In *2016 5th Mediterranean Conference on Embedded Computing (MECO)* (pp. 485-488). IEEE.
[12] Alam, K. M., Saini, M., & El Saddik, A. (2014, September). tnote: A social network of vehicles under internet of things. In *International Conference on Internet of Vehicles* (pp. 227-236). Springer International Publishing.
[13] Vrushali Pavitrakar and Navnath Kale (2016), Vehicular Messaging In IOT Using Epidemic Routing. International Journal of Computer Applications Technology and Research, 5(3), 137-140.
[14] Nitti, M., Girau, R., Floris, A., & Atzori, L. (2014, May). On adding the social dimension to the internet of vehicles: Friendship and middleware. In *Communications and Networking (BlackSeaCom), 2014 IEEE International Black Sea Conference on* (pp. 134-138). IEEE.
[15] Alam, K. M., Saini, M., & El Saddik, A. (2015). Toward social internet of vehicles: Concept, architecture, and applications. *IEEE Access*, *3*, 343-357.
[16] Wan, J., Liu, J., Shao, Z., Vasilakos, A. V., Imran, M., & Zhou, K. (2016). Mobile crowd sensing for traffic prediction in internet of vehicles. *Sensors*, *16*(1), 88.
[17] Prinsloo, J., & Malekian, R. (2016). Accurate Vehicle Location System Using RFID, an Internet of Things Approach. *Sensors*, *16*(6), 825.
[18] Choi, O.; Kim, S.; Jeong, J.; Lee, W.H.; Chong, S. Delay-optimal data forwarding in vehicular sensor networks. In Proceedings of the IEEE 11th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt), Tsukuba Science City, Japan, 13–17 May 2013; pp. 532–539.
[19] Liu, Y.; Li, S. A vehicle-logo location approach based on edge detection and projection. In Proceedings of the IEEE International Conference on Vehicular Electronics and Safety (ICVES), Beijing, China, 10–12 July 2011; pp 165–168.
[20] Saqib, M.; Lee, C. Traffic control system using wireless sensor network. In Proceedings of the 12th IEEE International Conference on Advanced Communication Technology (ICACT), Phoenix Park, Korea, 7–10 February 2010; pp. 352–357.

[21] Arbabi, H.; Weigle, C.M. Using DTMon to monitor transient flow traffic. In Proceedings of the IEEE Vehicular Networking Conference (VNC), Jersey City, NJ, USA, 13–15 December 2010; pp. 110–117.

[22] Chao, K.H.; Chen, P. An intelligent traffic flow control system based on radio frequency identification and wireless sensor networks. Int. J. Distrib. Sens. Netw. **2014**, 2014, 1–10.

[23] Bazzi, A.; Masini, M.B.; Zanella, A.; Pasoloni, G. Vehicle-to-vehicle and vehicle-to-roadside multi-hope communications for vehicular sensor networks: Simulations and field trial. In Proceedings of the IEEE International Conference on Communication workshops (ICC), Budapest, Hungary, 9–13 June 2013; pp 515–520.

[24] Alexander, P.; Haley, D.; Grant, A. Co-operative intelligent transport system: 5.9-GHz field trials. IEEE Proc. 2001, 99, 1213–1235.

[25] Cabezas, C.A.; Medina, G.R.; Pea, T.M.N.; Labrador, A.M. Low energy and low latency in wireless sensor networks. In Proceedings of the IEEE International Conference on Communications (ICC-09), Dresden, Germany, 14–18 June 2009; pp. 1–5.

[26] Zhou, J.; Member, S.; Chen, C.; Chen, L.; Zhao, W. A user-customizable urban traffic information collection method based on wireless sensor networks. IEEE Trans. Intell. Transp. Syst. 2013, 14, 1–10.

[27] Mazloumi, E.; Asce, M.S.; Currie, G.; Rose, G. Using GPS data to gain insight into public transport travel time variability. J. Transp. Eng. 2010, 136, 623–631.

[28] Friesen, M.; Jacob, R.; Grestoni, P.; Mailey, T.; Friesen, R.M.; McLeod, D.R. Vehicular traffic monitoring using Bluetooth scanning over a wireless sensor networks. Can. J. Electr. Comput. Eng. 2014, 37, 135–144.

[29] Bruno, R.; Nurchis, M. Robust and efficient data collection schemes for vehicular multimedia sensor networks. In Proceedings of the IEEE 14th International Symposium and Workshops on World of Wireless, Mobile and Multimedia Networks (WoWMoM), Madrid, Spain, 4–7 June 2013; pp. 1–10.

[30] Ahmad, F.; Khan, I.; Mahmud, A.S.; Khan, M.G.; Yousaf, Z.F. Real time evaluation of shortest remaining processing time based schedulers for traffic congestion control using wireless sensor networks. In Proceedings of the IEEE International Conference on Connected Vehicles and Expo (ICCVE), Las Vegas, NV, USA, 2–6 December 2013; pp. 381–387.

[31] Knorr, F.; Baselt, D.; Schreckenberg, M.; Mauve, M. Reducing traffic jams via VANETs. IEEE Trans. Veh. Technol. 2012, 61, 3490–3498.

[32] Abishek, C.; Kumar, M.; Kumar, P. City traffic congestion control in India scenario using wireless sensor network. In Proceedings of the Fifth IEEE Conference on Wireless Communication and Sensor Networks (WCSN), Allahabad, India, 15–19 December 2009; pp. 1–6.

[33] Xiao, L.; Peng, X.; Wang, Z.; Xu, B.; Hong, B. Research on traffic monitoring network and its traffic flow forecast and congestion control model based on wireless sensor networks. In Proceedings of the IEEE International conference on Measuring Technology and Mechatronics Automation (ICMTMA), Zhangjiajie, China, 11–12 April 2009; pp. 142–147.

[34] Dragoi, V.; Dobre, C. A model for traffic control in urban environments. In Proceedings of the 7th IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), Istanbul, Turkey, 4–8 July 2011; pp. 2139–2144.

[35] Du, R.; Chen, C.; Yang, B.; Lu, N.; Guan, X.; Shen, X. Effective urban traffic monitoring by vehicular sensor networks. IEEE Trans. Veh. Technol. 2015, 64, 273–286.

[36] Eren, H.; Pakka, M.H.; AlGhamdi, S.A.; Yue, Y. Instrumentation for safe vehicular flow in intelligent traffic control systems using wireless networks. In Proceedings of the IEEE International conference on Instrumentation and Measurement Technology (I2MTC), Minneapolis, MN, USA, 6–9 May 2013; pp 1301–1305.

[37] Skordylis, A.; Trigoni, N. Efficient data propagation in traffic-monitoring vehicular networks. IEEE Trans. Intell. Transp. Syst. **2011**, 12, 680–694.

[38] Wu, G., Talwar, S., Johnsson, K., Himayat, N., & Johnson, K. D. (2011). M2M: From mobile to embedded internet. *IEEE Communications Magazine*, *49*(4), 36-43.

[39] Booysen, M. J., Gilmore, J. S., Zeadally, S., & Van Rooyen, G. J. (2012). Machine-to-machine (M2M) communications in vehicular networks.

[40] Verma, P. K., Verma, R., Prakash, A., Agrawal, A., Naik, K., Tripathi, R., ... & Abogharaf, A. (2016). Machine-to-Machine (M2M) communications: A survey. *Journal of Network and Computer Applications*, *66*, 83-105.

[41] Soorki, M. N., Mozaffari, M., Saad, W., Manshaei, M. H., & Saidi, H. (2016). Resource Allocation for Machine-to-Machine Communications with Unmanned Aerial Vehicles. *arXiv preprint arXiv:1608.07632*.

[42] Shafiq, M. Z., Ji, L., Liu, A. X., Pang, J., & Wang, J. (2012). A first look at cellular machine-to-machine traffic: large scale measurement and characterization. *ACM SIGMETRICS Performance Evaluation Review*, *40*(1), 65-76.

[43] Doppler, K., Yu, C. H., Ribeiro, C. B., & Janis, P. (2010, April). Mode selection for device-to-device communication underlaying an LTE-advanced network. In *2010 IEEE Wireless Communication and Networking Conference* (pp. 1-6). IEEE.

[44] Doppler, K., Rinne, M., Wijting, C., Ribeiro, C. B., & Hugl, K. (2009). Device-to-device communication as an underlay to LTE-advanced networks. *IEEE Communications Magazine*, *47*(12), 42-49.

[45] Tehrani, M. N., Uysal, M., & Yanikomeroglu, H. (2014). Device-to-device communication in 5G cellular networks: challenges, solutions, and future directions. *IEEE Communications Magazine*, *52*(5), 86-92.

[46] Jänis, P., Yu, C. H., Doppler, K., Ribeiro, C., Wijting, C., Hugl, K., & Koivunen, V. (2009). Device-to-device communication underlaying cellular communications systems. *International Journal of Communications, Network and System Sciences*, *2*(3), 169.

[47] Chen, R., Zhong, Z., Leung, V. C., & Michelson, D. G. (2016). Link connectivity under more realistic channel model for vehicle-to-vehicle communications. *International Journal of Ad Hoc and Ubiquitous Computing*, *22*(1), 35-47.

[48] Biswas, S., Tatchikou, R., & Dion, F. (2006). Vehicle-to-vehicle wireless communication protocols for enhancing highway traffic safety. *IEEE communications magazine*, *44*(1), 74-82.

[49] Lyu, C., Gu, D., Zeng, Y., & Mohapatra, P. (2016). PBA: Prediction-Based Authentication for Vehicle-to-Vehicle Communications. *IEEE Transactions on Dependable and Secure Computing*, *13*(1), 71-83.

[50] Luo, Y., Xiang, Y., Cao, K., & Li, K. (2016). A dynamic automated lane change maneuver based on vehicle-to-vehicle communication. *Transportation Research Part C: Emerging Technologies*, *62*, 87-102.

[51] A Paul, A Daniel, A Ahmad, S Rho, Cooperative cognitive intelligence for internet of vehicles. IEEE Systems Journal, 11(3), 1249-1258. (2017).
[52] SR Alfred Daniel,Anand Paul,Awais Ahmad, Cooperative intelligence of vehicles for intelligent transportation systems (ITS). Wireless Personal Communications, 87(2), 461-484. (2016).
[53] Rathore, M. M., Son, H., Ahmad, A., & Paul, A. (2017). Real-time video processing for traffic control in smart city using Hadoop ecosystem with GPUs. Soft Computing, 1-12.
[54] A Paul, A Ahmad, MM Rathore, S Jabbar, Smartbuddy: defining human behaviors using big data analytics in social internet of things m IEEE Wireless Communications 23 (5), 68-74, 2016
[55] A Daniel, K Subburathinam, A Paul, N Rajkumar, S Rho, "Big autonomous vehicular data classifications: Towards procuring intelligence in ITS, Vehicular Communications 2017
[56] A Paul, TAA Victoire, AE Jeyakumar,"Particle swarm approach for retiming in VLSI", Circuits and Systems, 2003 IEEE 46th Midwest Symposium on 3, 1532-1535, 2013

Authour biography

Priyan Malarvizhi Kumar is currently pursuing a PhD in the Vellore Institute of Technology University. He received my Bachelor of Engineering and Master of Engineering degree from Anna University and Vellore Institute of Technology University, respectively. His current research interests include Big Data Analytics, Internet of Things, Internet of Everything, and Internet of Vehicles in Healthcare. He is the author/co-author of papers in international journals and conferences.

Usha Devi Gandhi is working as an Associate Professor in the School of Information Technology and Engineering, Vellore Institute of Technology University. She received her Bachelor of Engineering and Master of Engineering degree from the Anna University. Her Current research interests include big data analytics and wireless networks. She has published number of international journals and conferences. She is a member of CSI and IEEE.

Gunasekaran Manogaran is working in University of California, Davis, USA. He has received his PhD from the Vellore Institute of Technology University, India. He received his Bachelor of Engineering and Master of Technology from Anna University and Vellore Institute of Technology University respectively.

He has worked as a Research Assistant for a project on spatial data mining funded by Indian Council of Medical Research, Government of India. His current research interests include data mining, big data analytics and soft computing. He is the author/co-author of papers in conferences, book chapters and journals. He got an award for young investigator from India and Southeast Asia by Bill and Melinda Gates Foundation. He is a member of International Society for Infectious Diseases and Machine Intelligence Research labs.

Revathi Sundarasekar is currently pursuing PhD in the Anna University, Chennai, India. She received her Master of Computer Science and Engineering and Bachelor of Engineering in Computer Science from Anna University, Chennai, India. She is the author/co-author of papers in international journals, book chapters and conferences. Her current research interests include Big Data analytics, and Internet of Things.

Naveen Chilamkurti is currently working as a Senior Lecturer at Department of Computer Science and Computer Engineering, La Trobe University, Australia. He received his PhD from La Trobe University. He is also the Inaugural Editor-in-Chief for International Journal of Wireless Networks and Broadband Technologies launched in July 2011. He has published about 125 journal and conference papers. His current research areas include intelligent transport systems (ITS), wireless multimedia, wireless sensor networks, vehicle to infrastructure, vehicle to vehicle communications, health informatics, mobile communications, WiMAX, mobile security, mobile handover, and RFID. He currently serves on editorial boards of several international journals. He is a senior member of IEEE. He is also an Associate Editor for Wiley IJCS, SCN, Inderscience JETWI, and IJIPT.

Dr.R.Varatharajan received his B.E., M.E. and Ph.D. degrees all in Electronics and Communication Engineering from Anna University and Bharath University, India. His main area of research activity is Medical Image processing, Wireless Networks and VLSI Physical Design. He has served as a reviewer for Springer, Inderscience and Elsevier journals. He has published many research articles in refereed journals. He is a member of IEEE, IACSIT,IAENG, SCIEI and ISTE wireless research group. He has been serving as Organizing Chair and Program Chair of several International conferences and in the Program Committees of several International conferences. Currently he is working as a Associate professor in the Department of Electronics and Communication Engineering at Sri Ramanujar Engineering College, Chennai, India.